**NATURAL RESOURCES CONSERVATION SERVICE**

# CONSERVATION PRACTICE STANDARD

# TERRACE

**(feet)**
**CODE 600**

## DEFINITION

An earth embankment, a channel, or a combination ridge and channel constructed across the slope.

## PURPOSE

Terraces are constructed to (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) intercept and conduct surface runoff at a nonerosive velocity to a stable outlet, (5) retain runoff for moisture conservation, (6) prevent gully development, (7) reform the land surface, (8) improve farmability, (9) reduce flooding, or (10) improve water quality.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

1. Water erosion is a problem,
2. There is a need to conserve water,
3. The soils and topography are such that terraces can be constructed and farmed with a reasonable effort,
4. A suitable outlet can be provided, or
5. Runoff and sediment damages land or improvements downstream or impairs water quality.

## Scope

This standard applies to the planning and design of all types of terraces. It does not apply to the practice **Diversion** (362).

## CRITERIA

**Spacing.** Spacing shall be determined by one of the following methods:

1. Land in pineapple, sugarcane or orchards.

   Maximum horizontal terrace spacing shall be determined by using Table 1, but does not have to be less than 200 feet. The flattest field slope above any terrace will be used to determine the horizontal spacing at that point. The horizontal spacing shall not exceed 500 feet for land slopes up to 12 percent, 400 feet for slopes from 13 to 18 percent and 300 feet for slopes exceeding 18 percent. Terraces spaced with Table 1 should also be evaluated if possible with the USLE to determine the effect of the terrace system in reducing soil loss. Additional practices which will reduce soil loss to accepted limits should be recommended to the landuser.

2. Land in diversified agriculture.

   Maximum terrace spacing will be determined by the USLE but does not have to be less than 100 feet. The horizontal spacing shall not exceed 450 feet for land slopes up to 2 percent, 300 feet for land slopes of 2 to 4 percent, 200 feet for slopes of 4 to 6 percent and 150 feet for slopes of 6 percent and over.

Terraces spaced with the USLE shall be determined using the allowable soil loss, the most intensive use planned, and the expected level of management. The USLE "C" value may be adjusted to the expected level of management if the land user has made a firm decision or commitment to follow a planned conservation cropping system. The planned crop residue management, tillage operations, contouring, etc., shall be recorded in the cooperator's case file.

The following adjustments to spacing may be made on all terraces that are not limited by the maximum spacing for land slope. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10 percent for terraces with underground outlets. The spacing should be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths. The likelihood of benching of steep slopes by tillage, land forming, and erosion should be considered when determining the terrace interval. Terraces are not recommended on land slopes greater than 20 percent.

**Alignment.** Terraces shall be made parallel when feasible and as parallel as practicable in all cases. Curves should be long and gentle to accommodate farm machinery. Land forming, extra cut or fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods are to be used to achieve good alignment.

**Capacity.** The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have capacity to control a storm of a frequency consistent with the potential hazard. When the capacity is determined by the formula $Q = AV$ and the V is calculated by using Manning's formula, an "n" value of 0.06 shall be used for base channels. Engineering Field Manual Notice HA-11 "Terrace Channel Design Aid" may be used. For vegetated channels SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation," or equivalent, may be used with a "B" retardance factor.

**Cross section.** The terrace may have a steep backslope, steep backslope, and steep frontslope, broad base, or any other cross sectional shape that is stable and meets the other requirements in this standard.

Terrace cross sections are defined in the Engineering Field Manual (EFM), Chapter 8, Page 8-13. The terrace may be constructed by cutting, filling, or a combination of cut and fill, but shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. The ridge or fill portion, if any, of the terrace shall include a 10-percent overfill for settlement. The terrace ridge shall have a minimum width of 3 feet at the design elevation. For terraces constructed without a ridge, the design depths shall be measured where there is a minimum of 3 feet of horizontal soil width at the top of the downstream cut slope. The minimum slope of a vegetated front or back ridge slope is 2:1. If necessary, steeper slopes may be used for special purposes but must be stable. The opening at the outlet end of gradient and open end level terraces shall have a cross section equal to that specified for the terrace channel.

**End closures.** Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures will be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or underground outlets are provided.

Level terraces with end closures shall have sufficient storage available to store 80 percent of the runoff from the design storm before overtopping. Level terrace installation should be limited to soils in hydrologic soil groups A, A-1, and B. Hydrologic soil groups can be found in the Engineering Field Manual (EFM), Chapter 2.

When terraces with closed or partially closed ends are specified, the end closures must be installed before the terraces are considered complete. The end closures shall be designed so the water will flow over the end closure before overtopping the terrace ridge.

Partial end closures shall not be more than half the effective height of the terrace ridge. Full end closures are those more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

**Channel grade.** Maximum channel velocity shall be nonerosive for the soil and planned treatment. The following table shall be used to determine maximum permissible for bare channel velocities.

| Soil Erosion Resistance Group 1/ | Maximum Velocity (fps) |
|---|---|
| I | 5.5 |
| II | 4.5 |
| III | 3.5 |
| IV | 2.5 |

Velocities are to be computed by Manning's formula using an "n" value of 0.035.

1/ Soil erosion resistance groups for all Hawaii soils can be found in the EFM, Chapter 2.

Maximum channel velocities for permanently vegetated channels shall not exceed those used for grass waterways.

Channel grades will not exceed 3 percent even if maximum velocities are not exceeded. Channel grades may be uniform or variable. When terraces have an underground outlet, water and sediment will be ponded in the channel, thus reducing velocities and allowing steeper channel grades near the outlet. Minimum grades are to be such that ponding in the channel due to minor irregularities will not cause serious damage to crops or delay infield operations.

**Terrace lengths.** The volume of water stored in level terraces is proportioned to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break will be minimized. Level terrace length shall not exceed 2,000 feet. Gradient terrace length will normally be controlled by capacity and the nonerosive velocity requirement.

**Outlets.** All terraces must have adequate outlets:

1. Vegetated outlets may be used for gradient or open end level terraces. Such an outlet may be a grassed waterway or vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets are to be installed and vegetated before terrace construction, if necessary, to provide a stable nonerodible outlet or to insure establishment of vegetative cover. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.
2. Underground outlets may be used on all terraces. The underground conduit shall meet the requirements specified for underground outlets (Code 620).
3. Soil infiltration may be used as the outlet for level terraces. Soil infiltration should permit draining the design storm from the terrace channel in a period such that growing crops will not be significantly damaged by standing water.

4. Stable earth outlets may be used in areas where soils have proven resistance to erosion in that type of application. Usually, these outlets will be limited to soils in erosion-resistant groups I and II.
5. A combination of soil infiltration and nonerosive outlet may be used for level terraces with partial end closures.

Combinations of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system.

**Vegetation.** Steep backslope terraces (and steep frontslope, if used) shall be established to grass as soon as practicable after construction. Terraces constructed in fields with multiple year crops such as pineapple, sugarcane, and macadamia nuts that provide canopy cover to the steep portion of the terrace may not be practicable to establish to grass. The sod shall be maintained and trees and brush controlled by chemical or mechanical means. No trees shall be planted below the flow depth of gradient terraces

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge.
2. Variability effects caused by seasonal or climatic changes.
3. The type of outlet, time of water detention, topography and geology of the site.
4. Effects of snow catch and melt on water budget components.
5. Potential for a change in plant growth and transpiration because of changes in the volume of sol water.
6. Effects on the downstream flows or aquifers that could affect other water uses and users.
7. The effect on the water table suitable rooting depth for anticipated land uses.
8. Potential for water management to supple alternate uses.

### Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble sediment-attached substances that would be carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the visual quality of onsite and downstream water,
4. Short-term and construction –related effects on the quality of onsite and downstream water.
5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration I soils that have restrictive layers.
6. Potential for uncovering or redistributing toxic materials such as saline soils.
7. Effects on the movement of dissolved substances below the root zone and to the ground water.
8. Effects on wetlands and water related wildlife habitats.

## CONSTRUCTION PLANS

Plans for terrace systems shall be in accordance with this standard. Plans should include the location of each terrace in a field or the land slopes and horizontal spacing, cross section (depth, bottom width, sideslopes), length, channel slope, and type of outlet. If underground outlets are to be used, their plans may be incorporated into the terrace system plans.

TABLE 1

MAXIMUM TERRACE SYSTEM SPACING
(feet)
Hydrologic Class A Soils

| RAINFALL 10 - yr. 24 - hr. (inches) | SOIL EROSION RESISTANCE GROUPS | FIELD SLOPE (ft/ft) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 |
| 7 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | III | 500 | 500 | 500 | 470 | 420 | 380 | 350 | 340 | 300 |
| | IV | 430 | 350 | 300 | 270 | 260 | 230 | 200 | | |
| 8 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | III | 500 | 500 | 460 | 400 | 350 | 320 | 290 | 280 | 260 |
| | IV | 370 | 290 | 250 | 220 | 210 | 200 | | | |
| 9 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 500 | 500 | 480 | 400 | 390 | 380 | 300 |
| | III | 500 | 480 | 390 | 340 | 300 | 280 | 260 | 250 | 230 |
| | IV | 320 | 260 | 220 | 200 | | | | | |
| 10 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 350 | 480 | 430 | 380 | 350 | 340 | 300 |
| | III | 500 | 420 | 200 | 300 | 270 | 240 | 220 | 220 | 200 |
| | IV | 280 | 220 | 280 | | | | | | |
| 11 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 500 | 430 | 340 | 340 | 310 | 300 | 280 |
| | III | 500 | 380 | 310 | 270 | 210 | 220 | 200 | | |
| | IV | 250 | 200 | | | | | | | |
| 12 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 390 | 300 |
| | II | 500 | 500 | 460 | 390 | 340 | 310 | 280 | 280 | 250 |
| | III | 470 | 340 | 280 | 240 | 210 | 200 | | | |
| | IV | 230 | 200 | | | | | | | |
| 13 | I | 500 | 500 | 500 | 500 | 470 | 400 | 390 | 360 | 300 |
| | II | 500 | 500 | 420 | 360 | 320 | 280 | 260 | 250 | 230 |
| | III | 430 | 320 | 260 | 220 | 200 | | | | |
| | IV | 210 | 200 | | | | | | | |
| 14 | I | 500 | 500 | 500 | 500 | 430 | 390 | 360 | 330 | 300 |
| | II | 500 | 490 | 390 | 330 | 290 | 260 | 240 | 230 | 220 |
| | III | 400 | 290 | 240 | 210 | 200 | | | | |
| | IV | 200 | | | | | | | | |
| 15 | I | 500 | 500 | 500 | 470 | 400 | 360 | 340 | 310 | 290 |
| | II | 500 | 450 | 360 | 310 | 270 | 240 | 220 | 220 | 200 |
| | III | 370 | 270 | 220 | 200 | | | | | |
| | IV | 200 | | | | | | | | |
| 16 | I | 500 | 500 | 500 | 440 | 380 | 340 | 310 | 290 | 270 |
| | II | 500 | 430 | 340 | 290 | 260 | 230 | 210 | 200 | |
| | III | 350 | 260 | 210 | | | | | | |
| | IV | 200 | | | | | | | | |

TABLE 1
MAXIMUM TERRACE SYSTEM SPACING
(feet)
Hydrologic Class B – C - D Soils

| RAINFALL 10 - yr. 24 - hr. (inches) | SOIL EROSION RESISTANCE GROUPS | FIELD SLOPE (ft/ft) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 |
| 7 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 500 | 480 | 420 | 370 | 340 | 330 | 300 |
| | III | 500 | 420 | 340 | 300 | 260 | 240 | 220 | 210 | 200 |
| | IV | 270 | 220 | 200 | | | | | | |
| 8 | I | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 300 |
| | II | 500 | 500 | 490 | 420 | 370 | 330 | 300 | 290 | 270 |
| | III | 500 | 370 | 300 | 260 | 230 | 210 | 200 | | |
| | IV | 240 | 200 | | | | | | | |
| 9 | I | 500 | 500 | 500 | 500 | 490 | 400 | 400 | 380 | 300 |
| | II | 500 | 500 | 440 | 380 | 330 | 300 | 270 | 260 | 250 |
| | III | 450 | 330 | 270 | 240 | 210 | 200 | | | |
| | IV | 220 | 200 | | | | | | | |
| 10 | I | 500 | 500 | 500 | 500 | 450 | 400 | 370 | 340 | 300 |
| | II | 500 | 500 | 400 | 340 | 300 | 270 | 250 | 240 | 220 |
| | III | 410 | 300 | 250 | 210 | 200 | | | | |
| | IV | 200 | | | | | | | | |
| 11 | I | 500 | 500 | 500 | 480 | 410 | 360 | 340 | 310 | 300 |
| | II | 500 | 460 | 370 | 310 | 280 | 250 | 230 | 220 | 210 |
| | III | 370 | 280 | 230 | 200 | | | | | |
| | IV | 200 | | | | | | | | |
| 12 | I | 500 | 500 | 500 | 450 | 380 | 340 | 320 | 290 | 280 |
| | II | 500 | 430 | 340 | 290 | 260 | 230 | 210 | 210 | 200 |
| | III | 350 | 260 | 210 | 200 | | | | | |
| | IV | 200 | | | | | | | | |
| 13 | I | 500 | 500 | 490 | 420 | 360 | 320 | 300 | 270 | 250 |
| | II | 500 | 400 | 320 | 270 | 240 | 210 | 200 | 200 | |
| | III | 320 | 240 | 200 | | | | | | |
| | IV | 200 | | | | | | | | |
| 14 | I | 500 | 500 | 460 | 400 | 340 | 300 | 280 | 250 | 240 |
| | II | 500 | 380 | 300 | 260 | 220 | 200 | 200 | | |
| | III | 310 | 220 | 200 | | | | | | |
| | IV | 200 | | | | | | | | |
| 15 | I | 500 | 500 | 430 | 370 | 320 | 280 | 260 | 240 | 230 |
| | II | 490 | 360 | 290 | 240 | 210 | 200 | | | |
| | III | 290 | 210 | 200 | | | | | | |
| | IV | 200 | | | | | | | | |
| 16 | I | 500 | 500 | 410 | 360 | 300 | 270 | 250 | 230 | 220 |
| | II | 470 | 340 | 280 | 210 | 210 | 200 | | | |
| | III | 280 | 200 | | | | | | | |
| | IV | 200 | | | | | | | | |